The Role of Minimally Invasive Surgical Techniques in the Management of Large-gland Benign Prostatic Hypertrophy

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Lower urinary tract symptoms (LUTS) secondary to benign prostatic hypertrophy (BPH) are among the most common medical issues for aging men. Population-based studies suggest that 13.8% of men in their 40s and more than 40% of men over age 60 have BPH. When LUTS are refractory to medical therapy and bothersome enough to warrant surgical intervention, transurethral resection of the prostate and open simple prostatectomy have been the historical reference-standard procedures for decades. Both procedures are highly effective and offer durable improvements in urinary functional outcomes. However, they also have the potential for considerable perioperative complications and morbidity. In an effort to limit surgical morbidity, a variety of minimally invasive surgical techniques to treat BPH have been introduced. Herein we present a comprehensive, evidence-based review of the efficacy and safety profile of modern minimally invasive treatments for large-gland BPH.

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KEY WORDS

Benign prostatic hypertrophy • Lower urinary tract symptoms • GreenLight photovaporization • Holmium laser enucleation of the prostate (HoLEP) • Robotic simple prostatectomy

Lower urinary tract symptoms (LUTS) secondary to benign prostatic hypertrophy (BPH) are among the most common medical issues for aging men. Population-based studies suggest that 13.8% of men in their 40s and more than 40% of men over age 60 have BPH.[1] When LUTS are refractory to medical therapy and bothersome enough to warrant surgical intervention, transurethral resection of the prostate (TURP) and open simple prostatectomy (SP) have been the historical reference-standard procedures for prostates < 80 g and ≥ 80 to 100 g, respectively, for decades.[2]

Both procedures are highly effective and offer durable improvements in urinary functional outcomes.[3-5] However, they also have the potential for considerable perioperative complications and morbidity. A recent prospective study of more than 10,654 patients undergoing TURP reported an overall short-term morbidity rate of 11.1%. Among the most common complications reported were surgical reoperation (5.6%), transfusions (2.9%), and transurethral resection syndrome (1.4%).[6] Furthermore, the risks of both complications and mortality increased with gland size.[6] The morbidity of open SP is even higher, with 7.5% of patients requiring transfusions and 3.7% requiring surgical intervention for severe bleeding, even in contemporary series.[7]

In an effort to limit surgical morbidity, a variety of minimally invasive surgical techniques to treat BPH have been introduced. Although a large body of research exists investigating the overall safety and efficacy of such procedures, there remains a paucity of evidence regarding the safety and efficacy of these procedures in the management of large prostates ≥ 80 g in size (Figure 1).

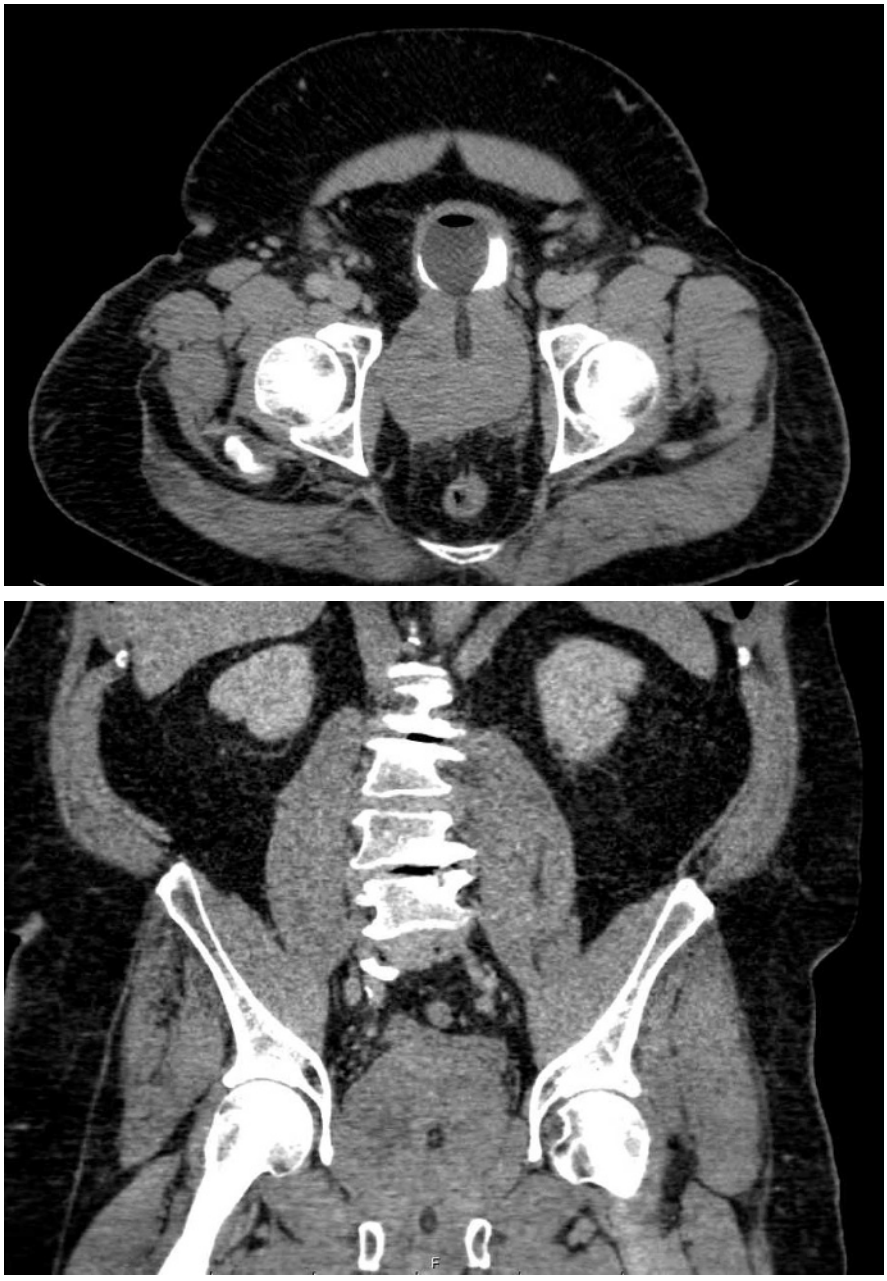

Figure 1. Example of large-gland benign prostatic hyperplasia on computed tomography scan in the axial (*above*) and coronal (*below*) planes.

Laser Therapy

The biggest change in surgical treatment of BPH over the past decade has been the introduction and use of lasers. A variety of lasers have been utilized with variable techniques, but the two with the greatest evidence supporting their use are the GreenLight XPS™ laser system (American Medical Systems, Minnetonka, MN) used for photovaporization (PVP), and holmium laser ablation of the prostate (HoLAP) and holmium laser enucleation of the prostate (HoLEP). Conceptually, PVP is based on the principle of applying laser energy to raise the temperature in order to either coagulate or vaporize prostate tissue. The energy emitted by a 532 nm GreenLight laser, which comes in an 80W, 120W, and 180W fiber, is absorbed by hemoglobin and preferentially heats well-vascularized prostatic tissue, thereby minimizing bleeding.[8] At

an energy level of 80 to 100W, the holmium laser allows for precise tissue cutting with simultaneous coagulation of blood vessels and minimal penetration into the tissue of approximately 2 mm.[9] In HoLAP, the adenoma is ablated in a similar fashion as with GreenLight PVP. In HoLEP, the laser is used to incise the prostate adenoma down to the level of the capsule, whereby the lobes are enucleated following natural tissue planes (Figures 2 and 3). The free lobes are then morcellated within the bladder using a tissue morcellator. Finally, the thulium laser, which is conceptually similar to the holmium laser, can also be used similarly for ablation and enucleation. This laser has gained interest over the past decade because it offers both a continuous and pulsed wave, which has the potential to create smoother cuts within the prostate. To date, comparison studies between the thulium and holmium lasers are limited. In the only randomized control study comparing laser enucleation procedures, the thulium laser was associated with less blood loss but longer operative time.[10] Outcomes were favorable in both groups, suggesting that functional outcome may be more a reflection of technique—in this case enucleation—rather than the specific laser used.[11]

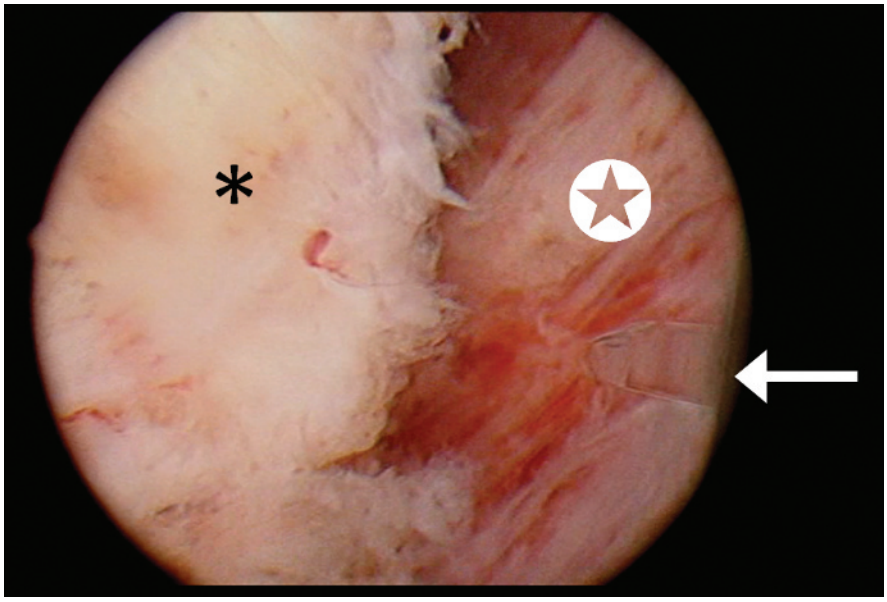

Figure 2. Holmium laser fiber (*arrow*) dissecting adenoma (*asterisk*) from capsule (*star*) during holmium laser enucleation of the prostate.

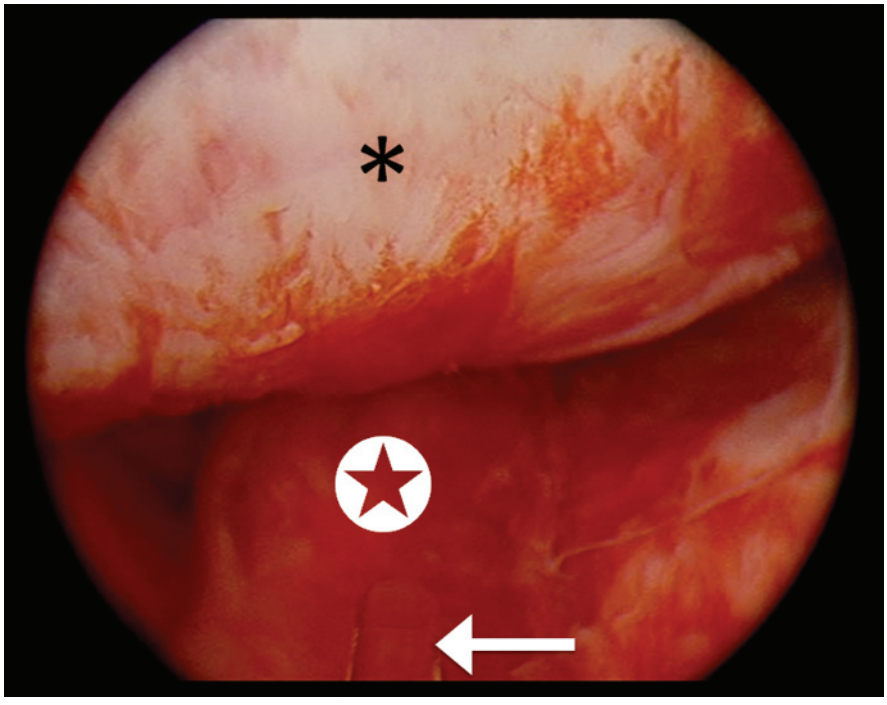

Figure 3. Image taken during holmium laser enucleation of the prostate after apical dissection of the left lateral lobe. The freed lobe (*asterisk*) can be seen floating above the veromontanum (*star*).

GreenLight Photovaporization

The majority of randomized trials investigating GreenLight PVP have compared it with TURP. This laser system has found favor within the urology community, likely due to its short learning curve for operators, its ability to be used in an ambulatory setting on patients taking anticoagulants, and its decreased risk of causing bleeding and dilutional hyponatremia.[12] As of 2011, approximately 20% of all transurethral prostate procedures in the United States were performed using the GreenLight laser, compared with 60% that were TURP, and the remainder with alternative technologies.[13] A recently published multicenter randomized noninferiority trial concluded that PVP produced outcomes, complication-free rates, and overall reintervention rates similar to those of TURP at 1-year follow-up.[14] In a 2012 meta-analysis of randomized controlled trials comparing GreenLight PVP (80W/120W) and TURP, PVP was found to have a better safety

profile with an 84% lower transfusion rate and no difference in other complications at 1-year follow-up. Hospital stay and catheter times were shorter in the PVP group by 2.1 and 1.9 days, respectively, and functional improvements as measured by maximum flow rate (Q_{max}) and International Prostate Symptom Scores (IPSS) were equivalent at 1-year follow-up.[15] It should be noted, however, that studies supporting improvements in long-term functional outcomes are limited, leading to criticism within the field that the increased utilization of GreenLight systems is not scientifically justified and is based on insufficient, low-level evidence with limited follow-up.[16] Furthermore, there is concern that the efficacy of this technique may depend on gland size, with poorer outcomes specifically among men with large-gland BPH.

Two randomized controlled trials included in the aforementioned meta-analysis did show improved functional outcomes with TURP compared with PVP. Notably, both of these studies compared patients with larger prostates > 70 and 80 g, respectively.[17,18] Horasanli and colleagues[17] randomized men with glands between 70 and 100 mL to TURP or PVP with an 80W potassium titanyl phosphate laser and found that, although both cohorts had improved outcomes at 6-month follow-up, men undergoing TURP had greater reductions in prostate volume (63% vs 41%) and prostate-specific antigen (PSA; 45% vs 32%), better IPSS (6.4 vs 13.1), and greater increase in Q_{max} (20.7 mL/s vs 13.3 mL/s). Further, 18% of the PVP group required reintervention compared with none in the TURP group.[17] Pfitzenmaier and colleagues[19] also demonstrated increased need for retreatment when PVP was performed in men with large versus small glands. Overall, 23% of men with prostate volumes > 80 mL required reintervention at nearly 1-year follow-up, compared with 10.4% of men with prostates < 80 g. Data regarding outcomes using the 120W and 180W laser systems are more limited given the relatively recent introduction of these devices; however, each has shown the potential for improved efficacy in the treatment of larger glands. Gu and associates[20] compared results of PVP with a 120W fiber in men with glands > 80 mL versus < 80 mL and found no significant differences in improvement; none of the 207 patients included in the study required reintervention at 36 months. The 180W fiber has similarly been used in men with large prostates > 80 mL in a study by Bachmann and associates,[21] and although overall results were favorable, 16% of procedures on these large glands required use of a TURP loop for optimization.

HoLEP

HoLEP is the endoscopic technique conceptually closest to SP. Advantages of HoLEP relative to TURP are similar to those of PVP, with a more substantial degree of evidence supporting its efficacy, especially among men with large glands.[22,23] Additionally, the durability of the procedure has been well documented, with favorable reductions in IPSS and improvements in Q_{max} up to 10 years postprocedure.[24] One drawback, however, is the perceived longer learning curve among operators necessary to master the procedure.[25-27]

HoLEP has shown equivalent or superior outcomes relative to TURP. A 2007 meta-analysis by Tan and associates[28] comparing outcomes of HoLEP and TURP among seven randomized controlled studies found comparable efficacy with regard to improvements in IPSS, quality-of-life scores, and Q_{max}. There was, however, less bleeding, and shorter hospital lengths of stay and catheterization time for the HoLEP group, with an overall lower rate of peri- and postoperative adverse events (8.2% vs 16.2%). Outcomes favoring HoLEP over TURP were similarly reported in a 2010 meta-analysis by Ahyai and colleagues,[3] and a 2014 meta-analysis by Li and colleagues.[29] In fact, it is the only minimally invasive technique that has demonstrated statistically significant improvements in reduction of IPSS relative to TURP.[3]

An additional advantage of HoLEP over other endoscopic modalities is that outcomes do not appear to be compromised by gland size. Traditionally, urologists have favored open prostatectomy over TURP for glands > 80 to 100 g; however, published outcomes for HoLEP in such cases support it as an efficacious alternative. In a randomized control trial by Kuntz and coworkers,[30] analyzing outcomes of HoLEP and open prostatectomy in glands > 100 g, equivalent outcomes were noted at all time points up to 5 years with regard to postoperative American Urological Association (AUA) symptom scores (3.0 vs 3.0), Q_{max} (24.3 mL/s vs 24.4 mL/s), and postvoiding

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residual (PVR; 10.6 mL vs 5.3 mL). The procedures had equivalent rates of urethral strictures and bladder neck contractures requiring intervention (5% vs 6.7%). In addition to the inherent benefits of avoiding an abdominal incision and entry into the bladder, HoLEP also carried a lower risk of requiring transfusion (0% vs 13.3%), shorter length of catheterization (30 h vs 194 h), and shorter hospital stay (70 h vs 250 h).[30] It has been further suggested that these benefits also translate into cost savings. Salonia and coworkers[31] randomized patients with prostates > 70 g to either open prostatectomy or HoLEP and found that the costs associated with HoLEP were significantly less ($2919 vs $3556).

Furthermore, favorable outcomes for HoLEP have been shown to be independent of gland size. Humphreys and coauthors[32] compared outcomes of HoLEP among men grouped into three categories based on prostate volumes (< 75 g, 75-125 g, or > 125 g), and demonstrated equivalent postoperative outcomes among groups in terms of improvements in AUA symptom score, Q_{max}, and PSA level. In fact, HoLEP appears to be efficacious in men with even the largest glands. Krambeck and coauthors[33] assessed outcomes of HoLEP in men with glands > 175 g and found that, among 57 patients with a mean gland volume of 218 mL as measured by transrectal ultrasound (TRUS), 100% of patients successfully voided once the catheter was removed and no patients required recatheterization or reported incontinence. Mean enucleated tissue weight was 176.4 g and 6-month outcomes were notable for reductions in AUA symptom score (from 19 to 6.5), and in PSA (from 14.6 ng/mL to 0.78 ng/mL).[33]

Proponents of HoLEP are skeptical of the long-term efficacy of PVP, pointing out that PVP does not remove sufficient tissue for durable response.[34] Although long-term follow-up is lacking, two randomized controlled trials comparing HoLEP with GreenLight PVP suggest the advantage of HoLEP. Elmansy and colleagues[35] randomized patients with prostate volumes > 60 g to undergo either GreenLight PVP (120W) or HoLEP. The authors demonstrated equivalent improvements in IPSS between the two procedures at short-term follow-up, but found HoLEP to be superior in almost all other measurements, including Q_{max} (30 mL/s vs 24 mL/s), PVR (29 mL vs 65 mL), PSA (0.9 ng/mL vs 2.4 ng/mL), and percentage reduction in TRUS volume (78% vs 52%). Furthermore, 22% of cases using PVP required conversion to another modality (TURP or HoLEP), whereas none of the HoLEP procedures required conversion.[35] More recently, the same group performed a randomized, controlled study comparing GreenLight PVP (180W) to HoLEP. Mean gland size was 87 g in the HoLEP cohort and 83 g in the PVP cohort. Although the PVP group demonstrated noninferiority in terms of reduction in IPSS and PVR at 1-year follow-up, it was inferior to HoLEP in a number of other perioperative and postoperative domains, including Q_{max} (26.4 mL/s vs 18.4 mL/s), reduction in PSA (82.6% vs 42.9%), percentage reduction in TRUS volume (74% vs 43%), and cost ($1760 vs $2658). Additionally, nearly 40% of the PVP-treated cases required intraoperative conversion to monopolar TURP for either hemostasis or residual tissue, compared with just 4% of the HoLEP-treated cases. Finally, two patients in the PVP group required reoperation compared with none in the HoLEP group; both had a large initial TRUS volume (89 g and 127 g).[36]

Bipolar TURP

A bipolar electrode features two active electrodes attached in a way that allows high-frequency electric current to pass between the electrodes.[37] In its application to TURP, the electrical current is applied using physiologic saline as the conductive irrigant, which minimizes the likelihood of postoperative hyponatremia. Another advantage of bipolar TURP is that a bipolar loop is virtually indistinguishable from a monopolar loop, and is utilized in the same fashion; thus, this technique has a minimal learning curve for a urologist familiar with TURP resections. With 4 years of follow-up in a randomized, prospective trial comparing bipolar and monopolar TURP, Autorino and colleagues[38] reported similar mean IPSS, Q_{max}, and PVR. Xie and colleagues[39] reported similar results in a randomized controlled trial with 5 years of follow-up. Results from meta-analyses of randomized trials also suggest that bipolar TURP is as equally efficacious as standard TURP in short- to medium-term follow-up.[40,41] It should be noted, however, that all three meta-analyses found the quality of trials available in the literature to be generally poor.[40-42]

Bipolar technology offers several potential safety advantages compared with standard monopolar TURP in the surgical management of large glands. Resection occurs at a much lower temperature, which may reduce the risk of thermal damage to surrounding structures,[37] particularly in the context of an extended resection. Furthermore, the use of isotonic saline irrigant may eliminate the

risk of hyponatremia altogether. A recent meta-analysis of 17 randomized trials comparing bipolar and monopolar TURP reported 0 instances of transurethral resection syndrome in the 675 patients who underwent bipolar TURP as compared with 10 instances in the 678 patients undergoing monopolar TURP.[42] This advantage is of particular utility in the management of large glands, as it may allow surgeons to extend the time of resection without fear of inducing hyponatremia. Intuitively, it is likely that this advantage would allow surgeons to resect a larger volume of tissue during bipolar TURP as compared with monopolar TURP. Some studies have reported that both techniques result in similar volumes of resected tissue,[43,44] whereas others have reported less resected tissue with the bipolar loop.[45] Several prospective, randomized studies have demonstrated that bipolar resection is associated with less blood loss,[46-50] fewer transfusions,[49,50] shorter length of catheterization,[45-47,49,50] fewer instances of clot retention,[50] and shorter hospital stay[45-47,50] as compared with standard TURP. This improved safety profile has been confirmed by all three recent meta-analyses, which demonstrated bipolar TURP to be associated with fewer instances of clot retention and blood transfusion, as well as shorter durations of postoperative catheterization and irrigation.[40-42]

Several prospective, randomized studies have demonstrated that bipolar resection is associated with less blood loss, fewer transfusions, shorter length of catheterization, fewer instances of clot retention, and shorter hospital stay as compared with standard TURP.

The body of literature investigating the safety and efficacy of bipolar resection in the management of large-gland BPH is also somewhat sparse. A retrospective study investigating bipolar TURP in the management of prostates 60 to 80 g vs those ≥ 80 g in size found no significant differences at 3-year follow-up in IPSS, Q_{max}, or PVR.[51] The cohort with larger glands did experience significantly longer operative times (96.1 min vs 67.6 min), more hemoglobin loss (1.67 g/dL vs 1.47 g/dL), longer catheter duration (82.7 h vs 69.0 h), and longer hospital stay (149.6 h vs 117.0 h); however, the clinical significance of those differences is questionable. Long and associates[52] compared bipolar TURP with open prostatectomy in a prospective but nonrandomized study of patients with prostate volumes 100 to 150 g in size and found no significant difference in urinary outcomes with 12 months of follow-up. Although there were fewer transfusions and instances of additional interventions for hemostasis in the bipolar TURP group, these differences were not statistically significant.

Although the body of literature investigating the safety and efficacy of bipolar TURP is generally small, it does suggest that it provides similar urinary outcomes of monopolar TURP in the management of prostate glands < 60 to 80 g and ≥ 80 g in short- to medium-term follow-up. Furthermore, it offers the additional benefit of an improved safety profile with respect to overall blood loss, need for blood transfusions, and length of postoperative catheterization, bladder irrigation, and hospitalization. Although this procedure may have a shorter operator learning curve as compared with other endourologic techniques,[34] there is little to no evidence at this time directly comparing bipolar TURP and open prostatectomy or newer endourologic techniques such as HoLEP or GreenLight prostatectomy in the management of large-gland BPH. Thus, at present, the body of literature investigating bipolar TURP is neither robust nor mature enough to draw definite conclusions regarding its long-term durability or its relative efficacy in comparison with open prostatectomy or other newer endourologic techniques.

Laparoscopic SP

The 2013 European Association of Urology guidelines still describe open SP as "the treatment of choice for large glands (> 80-100 mL)."[2] Open SP is highly effective in the treatment of BPH and has been demonstrated to result in 60% to 87% improvement in quality-of-life score, a mean increase in Q_{max} of 375%, and a reduction in PVR of 86% to 98%.[2,5,30,53] The procedure does, however, carry a significant risk of perioperative morbidity. In 2004, Varkarakis and coworkers[5] reported outcomes on men with prostates > 75 g. Overall, 7.5% of patients required transfusions and 3.7% required surgical revision for severe bleeding. The risks can be even greater in those with larger prostates; another recent retrospective series reported that open SP in glands >120 g resulted in a 30.4% blood transfusion rate, a 67% rate of low-grade complications, and a 15.1% rate of high-grade complications.[54] Since its initial description in 2002,[55] laparoscopic SP—both with and without robotic assistance—has been suggested to obtain similar functional outcomes as open SP with a lower risk of perioperative complications.[56,57]

At present, the literature examining the safety and efficacy of pure

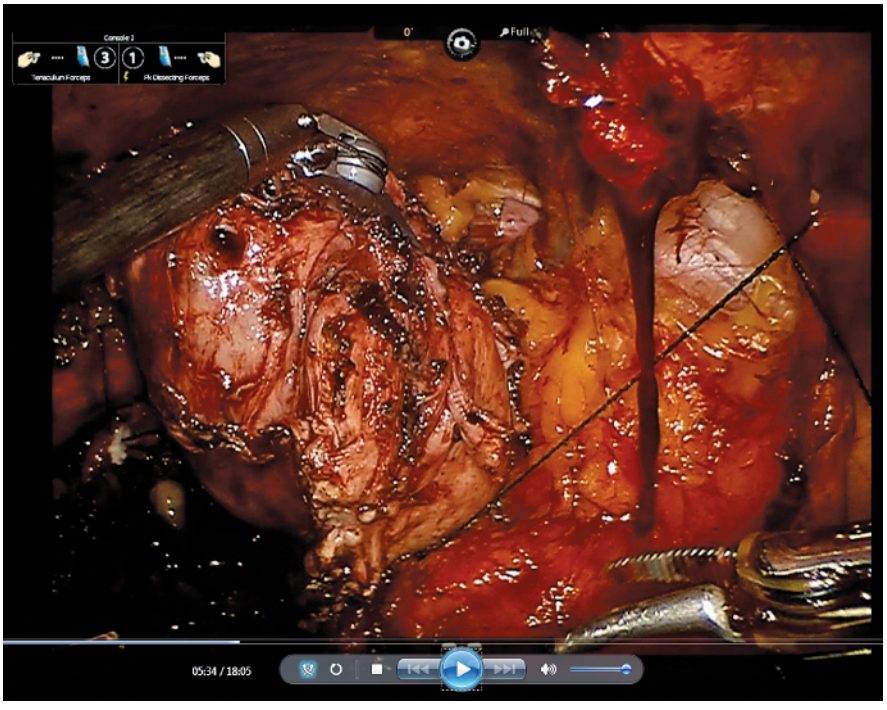
laparoscopic or robot-assisted SP is limited. Many studies have no comparison group,[56-59] whereas other series report outcomes of the procedure performed on patients with glands small enough to be candidates for alternative transurethral, less-invasive procedures.[60] To our knowledge, no randomized trials exist to date that evaluate this technique in the management of large-gland BPH exclusively.

The limited data available on laparoscopic SP suggest that it may be an efficacious technique in the management of large-gland BPH, with potentially less morbidity than open SP (Figure 4). In a comparative, retrospective study of 280 patients, McCullough and colleagues[61] reported that laparoscopic SP resulted in a shorter length of catheterization, shorter length of hospitalization, and lower risk of infectious complications as compared with open SP. They did not, however, find any difference between the two techniques in operative blood loss or time of continuous bladder irrigation. In a similar, but smaller, retrospective analysis, Baumert and associates[59] reported that laparoscopic SP was associated with significantly less blood loss and bladder irrigation time, in addition to shorter length of catheterization and hospitalization as compared with the open procedure. There were no differences noted in specimen weight or postoperative IPSS or Q_{max}. Moreover, the improvements in IPSS and flow rate following laparoscopic SP have been demonstrated to remain stable for at least 1 year postoperatively,[62] though longer-term follow-up regarding functional urinary outcomes is currently lacking in the literature.

A recent series of 25 robotic-assisted SPs in glands of mean size 149.6 g reported a mean hemoglobin loss of 2.7 g/dL and a 4% transfusion rate overall.[57] At a mean follow-up of 6 months, patients reported significant improvements in IPSS, Q_{max}, and PVR. Other smaller series have reported similar results, also with less than 1 year of follow-up.[56,63,64] The largest study of laparoscopic/robotic SP comes from Autorino and coworkers,[65] who compiled data from 23 institutions performing this procedure. They declared the procedure to be both safe and effective. Among the 1330 cases (487 robotic, 843 laparoscopic), mean prostate volume was 100 g and there was an overall intraoperative complication rate of 2.2%. Intraoperative transfusions were required in 3.5% and open conversion in 2% of cases overall. Patients stayed in the hospital an average of 4 days, with median time to catheter removal of 5 days. There were significant improvements in postoperative functional outcomes, including reduction in IPSS (23 to 4) and improvement in Q_{max} (5 to 22) which persisted at median follow-up of 1 year. Although estimated blood loss was less in the robotic group, improvements in outcomes did not differ between the laparoscopic and robotic cohorts.

Finally, a recent systematic review of 14 studies concluded that laparoscopic SP seemed safe and feasible, although evidence of its long-term outcomes as compared with open prostatectomy was limited.[66] Despite a paucity of long-term data regarding this emerging technique, interest in this approach among the wider urologic community remains high for a few reasons. It is possible that the application of laparoscopic and robotic skills, which are widely prevalent in the urologic community, to the performance of SP may be easier than overcoming the steep operator learning curve of HoLEP. Furthermore, a unique potential advantage of this approach is the ability to concomitantly perform a diverticulectomy or easily extract large bladder stones intraoperatively. Although there is currently insufficient evidence to consider

Figure 4. Enucleated specimen during a robotic simple prostatectomy.



either laparoscopic or robotic SP as the standard of care treatment in the management of large-gland BPH, the early evidence is promising enough to warrant further investigation in the form of randomized, prospective trials with long-term follow-up.

Future Perspectives

New technologies, including a variety of lasers, bipolar electrodes, and robotic surgical systems are now accepted surgical tools for the modern practicing urologist. Data supporting improved urinary functional outcomes after enucleation of the prostate, whereby the entire transition zone is removed, as opposed to partial resection, are becoming increasingly more common. Holmium enucleation and SP have the strongest evidence for improved urinary function in the treatment of large-gland BPH. Attempts are therefore being made to determine if there are additional minimally invasive ways to achieve enucleation.

Holmium enucleation and SP have the strongest evidence for improved urinary function in the treatment of large-gland BPH.

A recent prospective, randomized trial reported that a bipolar plasma enucleation of the prostate (BPEP) technique yielded significantly more resected tissue (56.4 g vs 43.3 g; $P < .001$) than monopolar TURP.[47] Moreover, in 2013, two separate randomized trials comparing a BPEP technique with open prostatectomy in prostates > 80 g demonstrated similar resected tissue weight and postoperative IPSS, Q_{max}, quality of life, PVR, and prostate volume between the two arms at 12 months of follow-up.[67,68] Perioperatively, however, the BPEP patients exhibited significantly less hematuria, smaller drops in hemoglobin postoperatively, and shorter periods of postoperative catheterization, bladder irrigation, and hospital stay. Specifically, Geavlete and colleagues[67] reported on 140 patients with prostate volumes > 80 g who were randomized to BPEP and open prostatectomy. Both groups had comparable tissue removed (108.3 g vs 115.4 g). Functional improvements were also equivalent in each group, with the BPEP group having less postoperative hematuria (2.9% vs 12.9%), smaller drop in hemoglobin (1.7 g/dL vs 3.1 g/dL), and shorter hospital stay (2.1 d vs 6.9 d). Length of catheterization was substantially shorter as well (1.5 d vs 5.8 d).[67]

BPEP has also been compared with HoLEP in a prospective, randomized trial with mean baseline gland size of 56.7 g in the HoLEP group and 60.3 g in the BPEP group. BPEP patients exhibited similar IPSS, quality of life, and Q_{max} rates at 2-year follow-up. Although operative time was shorter with BPEP (60.38 min for bipolar TURP vs 86.57 min for HoLEP; $P < .01$), the length of catheterization (85.11 h vs 79.2 h; $P < .05$), and hospital stay (4.37 d vs 3.55 d; $P < .01$) was longer for BPEP patients as compared with HoLEP patients. It should be noted, however, that HoLEP patients had more tissue resected (48.5 g vs 41.2 g; $P < .01$) and less postoperative hemoglobin drop (1.1 g/dL vs 1.3 g/dL; $P < .01$).[69]

Finally, a technique utilizing the GreenLight laser for anatomic enucleation has been recently described.[70,71] Although prospective and randomized data regarding use of this technique are not yet available, it appears to represent an appropriate evolution of the technique, particularly when applied to large prostates. Further comparison studies will be needed to consider the potential role of enucleation techniques that utilize existing technology in the treatment of large-gland BPH.

Conclusions

Several modern minimally invasive techniques are currently available for use in the treatment of large-gland BPH. Among the aforementioned techniques, HoLEP has the most evidence supporting its use, with equivalent results to open SP and with less morbidity. However, the steep operator learning curve required to successfully perform this procedure, especially on the largest glands, and the corresponding lack of practitioners who are able to perform this procedure, remain a challenge warranting the consideration of alternative techniques. Although there is interest in using bipolar and GreenLight techniques in the management of large-gland BPH, at present, the body of literature investigating the efficacy and durability of functional outcomes at long-term follow-up remains generally lacking. There is emerging interest in utilizing bipolar and GreenLight technology for the enucleation of large glands (perhaps with less of an operator learning curve than HoLEP); however, such techniques remain investigational at present. Early data investigating laparoscopic and robotic SP appear particularly promising at short-term follow-up; however, without randomized prospective evidence, the role of this procedure relative to established techniques such as HoLEP remains unclear.

A number of promising new endoscopic and minimally invasive technologies are available for use in the treatment of large-gland BPH. At present, HoLEP remains the best-studied

minimally invasive procedure with the longest evidence of durable follow-up. Although alternative techniques such as GreenLight PVP, bipolar resection, and enucleation and laparoscopic/robotic SP have shown efficacy in the management of large glands, there is a clear need for further randomized controlled trials investigating the comparative effectiveness of these techniques in relation to monopolar TURP, open prostatectomy, and HoLEP. ■

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MAIN POINTS

- Transurethral resection of the prostate and open simple prostatectomy (SP) have been the historical reference-standard procedures for prostates < 80 g and ≥ 80 to 100 g, respectively, for decades. Both procedures are highly effective and offer durable improvements in urinary functional outcomes; however, they also have the potential for considerable perioperative complications and morbidity.
- Among the newer endourologic techniques, holmium laser ablation of the prostate has the most evidence supporting its use in the management of large glands, but its steep learning curve has limited its widespread acceptance.
- Although there is great interest in applying bipolar and GreenLight techniques in the management of large-gland benign prostatic hypertrophy (BPH), the present body of literature investigating its efficacy and durability at long-term follow-up remains lacking.
- Although early data suggest that robotic and laparoscopic SP may be an efficacious technique in the management of large-gland BPH, with potentially less morbidity than open SP, more study is needed on this emerging technique.

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